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TOP SCHOLAR

NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2023
Biology

Time allowed: Three hours
Total score: 24

ANSWER BOOKLET

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

Write your answers in this booklet.

Start your answer to each question on a new page. Carefully number each question.

Check that this booklet has pages 2–27 in the correct order. Pages 2–4 are blank and are to be used for planning. Pages 5–27 are lined pages for writing your answers.

Do not write in any cross-hatched area ( ). This area may be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

PLANNING

- inbreeding depression
- loss of habitat
  - territory
- loss of prey species
- k selected species
- Traps, hunting car strikes
- Bacteria

PLANNING

PLANNING

several different factors have lead to the decline of the lynx population, mostly related to increased human activity in their habitat.

The main factor causing the initial decline of the population was ~~hunting~~ hunting by humans, either trophy hunting or pest control. Even though deliberate hunting was outlawed in the 1970s, indirect killing of lynx's occur through traps and snares by human hunters. this ~~hunting~~ increase in hunting from the 19th century onwards was an extreme selection pressure that rapidly declined the lynx population because as a predator species, the lynx hasn't ~~ev~~ evolved to survive purposeful predation by human beings. The iberian lynx is also a k-selected species. Females have a low birth rate ~~yearly~~ with a average of 3 kits (often decreasing to ≤2 after weening) and parents have to invest significant energy and time into raising the kits. The mother has to catch up to 3 rabbits a day to feed the kits and the kits stay dependent on the parent until 7-10 months and don't leave till 20 months. the young cats also don't begin to ~~mate~~ reproduce until they gain a territory, which can take up to 5 years. These k-type reproductive strategies ~~and~~, the slow sexual maturity and the low litter number (only around 3 a year) of the lynx means that the population grows very slowly and cannot replace itself with the added selection pressure of hunting. Lynx's get killed by hunters at a faster rate then they can reproduce and replace the lost individuals, leading to a decline in the population.

The territoriality of the lynx and the decrease in suitable habitat also contribute to their population decline. The lynx's hold territories up to 20km² and defend from one another. This is to reduce ~~intra~~-specific competition for space and food, however it also limits the amount of lynx's present in an area. with a huge decline in their heterogenous habitat, less land is available for lynx's to hold territory. This leads to ~~the~~ displaced individuals ~~not~~ losing their ~~food~~ hunting grounds and starving. or, individuals are forced to encroach on other lynx's territories, leading to violence between cats and a further reduction in population. since the lynx's females rarely breed unless they have a territory, less space for territory leads to less females holding territories, leading to less females reproducing and lowering the replacement birthrate of ~~the~~ the population //

the reduction in range and overall population size also makes finding mates more difficult, forcing individuals to mate within their own gene pools and inbreed. This leads to inbreeding depression, ~~where~~ as harmful recessive alleles emerge in ~~a~~ inbred individuals, causing detrimental effects to their chances of survival (eg. no coat growth, poor eyesight) inbreeding also leads to a reduction in overall genetic diversity. combined with the effect of genetic drift acting on the ~~lg~~ small lynx population, certain alleles can be fixed or lost, reducing the populations fitness in case of sudden ~~env~~ changes in selection pressures.

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Disease and bacteria are the final factors that have led to the population decline. Due to myxomatosis and haemorrhagic fever epidemics amongst the rabbit populations, the lynx's have lost ~~the~~ large numbers of their main ~~food~~ prey source. A decrease in rabbits leads to more lynx's starving to death and the death of kits as mothers cannot ~~get~~ capture the ≈3 rabbits a day needed for the kits energy demands. the outbreak of these diseases also threatens the health of the lynx population itself. In 2013, it was found that lynx's possess anti-biotic resistant bacteria in their digestive tracts, aquired from the environment. ~~ka~~ Since the genetic diversity of the lynx population is already low due to inbreeding and the population bottleneck, an outbreak of bacterial and infection could be catastrophic for the species as individuals are less likely to possess alleles to aid their survival during the outbreak due to alleles becoming fixed or lost, ~~ka~~ threatening extinction for the lynx population.

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* The lynx population also underwent a population bottleneck, with ~~only~~ less than 100 animals remaining. This ~~4~~ severe reduction in the population causes the bottleneck effect, where alleles from the original gene pool become lost and only a tiny diversity of the alleles remain in the surviving population, increasing their vulnerability to environmental changes and changes in selection pressures.

multiple interventions have been undertaken to avoid the extinction of the species.

The ~~bea~~ protection of the lynx species from hunting in the 1970s would have greatly reduced the deaths of lynx's and relieved ~~them~~ the species of their main selection pressure. By stopping hunting, less lynx's are killed, slowing the rate of population decline and potentially allowing the birthrate of the species to replace lost individuals and recover its previous size.

The creation of protected areas and the re-introduction of lynx's to previously inhabitated areas increases the amount of habitat avaliable to the lynx. By expanding their habitat and spreading individuals out, intraspecific competition amongst lynx's is reduced ~~away~~ among the small isolated populations. Lynx's are given more area to establish adequate territories, which makes more females reproductively viable and increases the birth rate of the species as more females can hold territory. The increased territory also increases the ~~food~~ prey population available to lynx's, meaning that it is more likely that females can catch a sufficient amount of rabbits to feed her kits, reducing the mortality of kits and increasing the population further. ✓

The building of highway tunnels and wildlife corridors reduce the likelihood of lynx's being hit by cars at random chance, since they can now cross the increasing amount of highways safely, reducing the amount of individuals killed, preventing further decline. ✓

The restocking of rabbits gives the lynx population greater food resources, reducing the deaths by starvation and allowing the population to grow with the additional food sources. ✓

The translocation of animals between populations helps to ensure that ~~allele~~ gene flow still occurs and alleles are not lost in isolated populations due to the bottleneck effect and genetic drift, ensuring that the gene pool remains diverse enough to survive changes in the environment. The ~~reti~~ introduction of non-related individuals also reduces the likelihood of inbreeding as new alleles are introduced. This reduces the amount of kits born with genetic defects, improving their chances of survival and leading to more reaching sexual maturity, growing the population.

These interventions have allowed the lynx population to grow from <100 individuals to 1110 in 2021

In order to achieve favourable conservation status, the population needs to grow to 3000-3500 individuals. In order to achieve this, the same interventions that were used to grow the population should be continued (the expansion of habitat, re-stocking of rabbits etc), but a few others should be implemented to ensure the long term viability of the population

Populations of rabbits could be treated with ~~anti-bi~~ anti-biotics, vaccines or the culling of sick individuals to prevent the outbreak of diseases like myxomatosis. Treatment of the rabbit population ensures that the main food source of the lynx ~~are~~ is stable in population and that the re-stocked rabbits are not lost to disease. The reduction in these diseases also protect the lynx population from catching ~~disea~~ ~~bu~~ infections from infected rabbits, further improving the populations chances of survival

Strategies to increase genetic diversity are essential to ~~to~~ prevent the effects of a population bottleneck. The 3000-3500 individuals need to have a larger gene pool in order to be less vulnerable to changes in the environment such as disease. Re-introduction of lost alleles could be done through the cloning / unfreezing of preserved lynx dna. Currently in captive breeding programs, lynx embryos have been frozen ~~a~~ for storage. If the genetic diversity of the population is low in the future, ~~genetic~~ alleles stored in these embryos could be reintroduced into the population to increase allele diversity. since lynxs were trophy hunted, preserved tissue of individuals from the original 14th century population might be viable to be used for cloning in order to ~~re-introduce~~ re-introduce lost alleles back into the lynx population

Question 2

The moa was the main selection pressure in the environment that ~~a~~ caused the evolution of heteroblasty in lancewood due to the moas herbivory

moas, ranging in height from that of a turkey to 3m tall, were the main ~~herbivores~~ and largest herbivores in New zealand's forests. The moa and the lancewood display co-evolution due to the moas herbivory of the lancewood.

The lancewood displays heteroblasty in order to avoid herbivory by the moa in its early life stages. Grazing from a moa would destroy the plant and potentially take off enough ~~of~~ leaves to either kill the plant or severly reduce its growth and chances of survival. ~~p~~ lancewood individuals which were able to avoid herbivory by the ~~moa w~~ moa were able to ~~reduce~~ increase their chances of survival and grow faster without losing energy to ~~they leave~~ growing back leaves, increasing their reproductive success and chances of survival.

The selection pressure of the moa ~~w~~ caused directional selection in the lancewood plant. plants that had rigid, barbed phenotypes on their leaves were less likely to be eaten by the moa due to physical harm done to the moa if eaten (cutting of the throat if ingested) compared to safe to eat leaves. Rigid, barbed individuals would have an increased chance of survival, reproducing ~~more~~ more and increasing the frequency of the alleles for sharp, rigid leaves, causing directional selection towards the phenotype seen today. //

~~Natur~~

This natural selection would also cause the differences in nutritional content between young and adult leaves. Lancewood plants that ~~produced~~ contained less protein and carbohydrates as a seedling would become ~~more~~ ~~on~~ less attractive to herbivores and ~~better~~ ~~a~~ conserve their energy by not investing it into their vulnerable leaves. Compared to seedlings with high nutrient density, these plants would be eaten less and lose less energy if a leaf was eaten, increasing their chance of survival and increasing the frequency of those alleles in the gene pool, causing evolution towards heteroblasty //

The creation and onset of certain random mutations ~~can~~ also helped ~~increase~~ contribute to heteroblasty and increase the lancewoods chances of survival. Random mutations would have occurred, such as the mutation that causes new leaves to be brown in colour, which while either ~~harm~~ harmful or neutral in other ~~sp~~ populations (lack of chlorophyll due to lack of green pigment, reduction in ~~e~~ photosynthesis), greatly increases the lancewoods chances of

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survival due to the camoflauge brown leaves ~~prod~~ provide. * plants with these ~~colour~~ random mutations (brown leaves and yellow spots on the ridges) ~~would~~ are more likely to avoid herbivory by the moa and reach adulthood, increasing the frequency of the mutated allele in the population. In this case, the colouration changes would have become fixed in the population as the allele frequency changed to 100%. //

After the lancewood reaches a height above ~~that~~ what moas can reach (3 metres for the tallest moa), the plant changes to have the leaves pointed up and begins to resemble a typical tree in the forest. This change in phenotype is due to the selection pressure of the moa disappearing after the plant exceeds a certain height. Without the moa as a selection pressure, the lancewood is subject to other selection pressures such as competition for sunlight and develops a ~~plant~~ phenotype more ~~suite~~ suited to the new ~~select~~ selection pressures (eg. green leaves to increase photosynthesis). The large difference in selection pressures acting on the lancewood plant between when its below 3 metres and above 3 metres have caused the plant to develop stark ~~heteroblasty~~ ~~le~~ heteroblasty in order to avoid herbivory from the moa species. C1

* Seen Since the brown leaves make the sapling difficult to spot to the moa, against a liter of leaves, the moa is unable to spot brown individuals and hence not eat their leaves. Additionally, mutations causing the bright spots on the leaves

edges are highly conspicuous to birds. This may be a form of ~~mimikrey~~ mimicry, with the imitation causing the leave to look poisonous or diseased, detering birds from eating it

The lancewood in the mainland and the ~~lance~~ chatham Island lancewood ~~show~~ show ~~a~~ divergent evolution. The two populations are geographically ~~isl~~ isolated by sea and have no gene flow between them. Allopatric speciation occured between the species due to differences in selection pressures between the mainland and chatham islands. The chatham islands did not have any browsing birds, so the population there did not have the same selection pressures of herbivory by ~~moas~~ moas on the mainland, so the chatham Island lancewood didn't evolve defense mechanisms and heteroblasty to protect itself from predation. The leaves do not change colour and do not have spots or spires on them.

~~Reasons~~ One reason the lancewood has retained its heteroblastic lifestyle despite the extinction of the moa is due to the moas not being extinct for long enough. The moa only went extinct around 600 years ago. The timeframe of large-scale evolutionary changes is much longer than 600 years. within 600 years, there hasn't been enough generations of the species for ~~the~~ previously unfavourable alleles (such as green sapling colouration and soft leaves) that would previously been selected against to re-emerge in the population and increase in allele frequency to cause meaningful changes to the species.

Additionally, there aren't any strong selection pressures against the heteroblastic lifecycle of lancewood. Traits such as downwards facing leaves, bright spots and tough spines are not directly harmful to the survival of the lancewood. Without selection pressures against these alleles, the allele frequency of the population will remain the same with the exception of genetic drift, which is random and ~~out fast~~ doesn't occur fast enough (especially in a large population) to have any noticable ~~affect~~ effect on the evolution of the lancewood within 600 years. //

Certain alleles such as those for green ~~sap~~ coloured saplings and soft leaves might have been lost in the gene pool due to the selection pressure of the moa, with ~~green~~ individuals carrying those alleles being eaten by moa and outcompeted by ~~better ada~~ better adapted plants, those alleles could be lost. meaning that the only way for new alleles to be introduced into the lancewood ~~p~~ population is ~~through~~ through random mutation, which is unpredictable ~~and~~ and slow //

the last reason the lancewood ~~could~~ is ~~retaining~~ retaining its heteroblastic life cycle ~~a~~ could be the introduction of new browsing herbivores into the NZ ecosystem. After moas went extinct, ~~deer~~ deer, goats and pigs were introduced to new zealand. Wild populations of these herbivores could have replaced the ~~eco~~ ecological niche ~~of the moa~~ the moa once inhabitanted. ~~as~~ since deers are large, browsing herbivores, they continue to exert selection pressures on the lancewood population to retain their ~~its~~ defensive mechanisms as saplings. Any lancewood plants without heteroblasty or with unfavourable traits like high nutrient dense leaves or no-spots might be instead eaten by deer and other mammals, preventing those alleles from being re-introduced back into the lancewood population.

Question 34

the biological species concept only works effectively on a sexually reproducing populations where distinct and obvious reproductive isolation is present between populations. Many times species are described off geographical seperation and differences in phenotype, however when species are brought together, the reproductive isolation ~~really~~ is revealed to not exist and the populations hybridize ~~fall~~ ~~with~~ with eachother.

The main example of this is between the parera and mallard duck species. Geographically they were very isolated, with the mallard originating from open grassland in ~~north american~~ the northern hemisphere while the parera is endemic to NZ (although closely related to other duck species in the pacific). ~~Extren~~ Externally, their phenotypes are also clearly different, with the mallard having a ~~distinctly~~ distinctly green head in males. however, their reproductive behaviour is still very similar. Both species have overlapping breeding and egg laying months, and clearly parera and mallards do recognize eachother as mates. This means that there are no/little pre-zygotic reproductive isolating mechanisms and evidently, neither do post-zygotic reproductive isolating mechanisms as hybrids are fertile and do not experience hybrid breakdown. As soon as the species are inhabiting the same range (NZ), previously assumed RIMs ~~cause~~ cease to exist as clearly the populations haven't been isolated geographically for long enough to develop other RIMs, such as behavioural RIMs or post-zygotic RIMs (different chromosome number or gamete ~~incompatibility~~ incompatability).

Similar examples are seen ~~a els~~ elsewhere. In North America, grizzly bears and polar bears remained ~~remained~~ seperate populations, with the polar bears ~~solely~~ solely inhabiting the artic ice. However with climate change, the polar bears are losing habitat and are forced further south to escape melting ice sheets, coming into ~~t~~ contact with grizzly bears. More and more hybrids between grizzly and polar bears are being sighted with both white and brown fur colourations.

Orcas and shortfinned pilot whales also often create hybrids ~~d~~ due to the two species, while ~~sta~~ starkly different in colouration, socialising together and cooperatively hunting. Although the species seem different, there are basically no behavioural RIMs ~~seperating~~ seperating the ~~two~~ two ~~da~~ blackfish species.

The concept of a species ~~a~~ is especially ~~vaug~~ blurry when applied to tropical reef fishes, especially those like the pipefish family. ~~Fish fa~~ Groups often rapidly speciate due to limited range ~~base reef~~ (seperate reefs) and change colouration dramatically. However when species are put in the same habitat ~~habitat~~, hybridisation occurs ~~occurs~~ freely and many ~~many~~ species are able to change their phenotype (colours) at will to better suit ~~suit~~ their new environment, making ~~fish~~ reef fish species incredibly hard to differentiate from the naked eye of a human. All these examples show how very ~~a~~ obvious differences to our perception, like range and phenotype, are only surface level and certain special groups/species can overcome RIMs that totally isolate other populations from eachother. 4

Alternative evidence to distinguish the mallard and parera species aside from ~~pheno~~ external soft-body features (feathers, colours, etc) include genetic markers, internal or hard-body features and differences in behaviour. 4

Definitive genetic studies have yet to be undertaken with either species. During their geographic seperation, it is very likely that mutations occured in the genomes of either species that are not present in the other. While these mutations might have no effect on RIMS, they could be used to determine a ducks genetic purity. — mtDNA analysis could be used to examine point mutations on the mtDNA of parere to determine which individuals are descended from the original parere population. However, mtDNA is passed solely from the mother so a hybrid could possess 100% parere mtDNA ~~a~~ if the female was parere. Nuclear DNA could be analysed to find unique mutations and alleles present in the parere population. ~~Hetero~~ homozygous individuals for these alleles would most likely be pure-bred parere as only parere parents could pass those alleles. These genetic markers, while unrecognizable to the average person, could help conservationist locate and isolate pure bred parere~~a~~ individuals. 4

~~Its small~~ The soft-part and plumage features of pāteke and mallards are hard to distinguish and harder to when it's a hybrid. However, less obvious features like skeletal structure could be used to ~~determine sp~~ distinguish species, as those features are hidden from plain view and could reveal more obvious differences/variation between the two species.

Lastly, certain behaviors or vocalisations of either species could be analysed for differences. A pāteke-mallard hybrid might use vocalisations that are an obvious mix of the two species due to co-parenting by both a mallard and a pāteke parent. Ducks that only had pāteke parents might have a distinct vocalisation that can be verified for authenticity.

The difficulties with the species concept between mallards and pāteke impacts decisions on conservation efforts for the pāteke.

Firstly, due to the rampant hybridisation and difficulty distinguishing between the 2 species, the shooting of pāteke by game hunters cannot be reliably policed and prevented. Since the mallard is very common, hunters are free to shoot them ~~a~~ however the critically endangered pāteke ~~ca~~ can be thrown into that mix and individuals could be lost without the overarching protection from conservation organisations. Additionally, the genetic mixing between the ducks creates tricky legal and biological ~~a~~ implications if the shooting of ~~patere~~ parera becomes regulated/banned, because at what point is a hybrid considered parera? If the hybridisation is widespread, there might be no individual ducks that can be accurately ~~ca~~ classified as ~~endangered~~ "endangered" or "free to shoot", making the regulation of hunting infeasible. 9

~~A~~ Secondly, with very few/no pure parera left, efforts to maintain a genetically intact population for conservation are further complicated. establishing only parera breeding populations ~~a~~ ~~only~~ might lead to the species detriment with so few individuals, inbreeding depression and ~~population~~ the bottleneck effect might decrease the fitness of the already critical parera population.
The declining number of parera also pose a ~~an~~ unclear question to conservationist. perhaps it is ~~no~~ better to preserve the genetic history of the parera species by allowing it to hybridize with a more successful species and keep the genes in the now mixed population rather than maintain a pure breeding population that is vulnerable to extinction, losing the parera genetic history forever. In the future, the now hybridised population of parera might become the only remnants of the original parera species, which may cause science to now

classify the hybrids as the new porera population and these mallard-porera hybrids recieve the full ~~pet~~ protection of a native species in NZ. perhaps the protection would have to extend to the entire mallard population in NZ

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